Title: Heating UP and Cooling DOWN

Brief Overview:

Students will use the CBL with the temperature probe to measure the amount of time it takes the probe to return to room temperature when removed from a container of water. They will record the data and enter it into the statistical lists on the TI-82/83, then observe the graph. They will then use the TI-82/83 to do a regression, getting the "best-fitting curve".

Links to Standards:

- **Mathematics as Problem Solving**
  Students will investigate the effect of water temperature in relation to air temperature over time and make predictions on their observations.

- **Mathematics as Communication**
  Students will work cooperatively to develop a generalization of their investigation and express their finding in writing.

- **Mathematics as Reasoning**
  Students will be able to make conclusions and conjectures based on the observed data.

- **Mathematical Connections**
  Students will recognize the connection between algebra and science (physical science, chemistry); and the real-life application in food preparation.

- **Algebra**
  Students will be able to represent situations involving time and temperature variables with equations. They will also use tables and graphs as tools to interpret equations.

- **Functions**
  Students will be able to represent and analyze a relationship using tables, rules, equations, and graphs.

- **Statistics**
  Students will be able to display data in a scatter plot and determine a function using a regression and curve of best fit.

Grade/Level:

Algebra I or higher

Prerequisite Knowledge:

Students should have working knowledge of the following skills:

- Identifying and graphing a simple function
- Entering data into the statistical lists on the TI-82/83
- Graphing a scatter plot on the TI-82/83
- Using the TI-82/83 to perform a regression to fit the data
- Copying a regression function into the "y=" list in order to graph it

Objectives:

Students will be able to:

- work in cooperative groups.
- collect data using the CBL with the temperature probe; and link the CBL and TI-82/83 to enter the data in a list.
- display the data in a scatter plot, temperature vs time.
- use the regression feature of the TI-82/83 to find the "best-fitting" curve.
- make predictions based on observed results.

Materials/Resources/Printed Materials:

- CBL's with temperature probes
- TI-82/83 calculator
- HEAT Program for calculator (if unavailable, digital watch or stopwatch)
- Containers of liquid (*very* hot water and ice water) for each group
- Hot plate to keep hot water at constant temperature (preferably, for each group)
- Ice chest to hold ice cubes
- Insulated safety gloves or potholders
- Facial tissues

Development/Procedures:

Students will work in groups of 2, 3, or 4.

Group leader - Keeps group on task; holds temperature probe in position
CBL Monitor - Readies CBL for experiment and operates CBL
Mathematician - Readies calculator for experiment and performs math operations
Recorder - Record analysis of data; makes sure activity sheets are complete.

Teacher will give a brief overview of the experiment and explain what is expected from the students.

Make sure each group has a copy of the HEAT Program. (The program can be linked from one calculator to another.)

Demonstrate connecting the heat probe to the CBL unit and linking the CBL unit to the TI-82/83 calculator.

Demonstrate the proper procedures for setting up the physical model for the time/temperature experiment.

Distribute probes, CBL's, and student instruction and activity sheets.

Each student in the group should receive an activity sheet so that some of the questions can be answered for homework.

Performance Assessment:

Teacher will circulate around the classroom to observe that each group is on task and following appropriate procedures of the activity. Activity sheets will be collected and evaluated. Group presentation of lab results is optional.

Extension/Follow Up:

Heat different foods and have students use the temperature probe to measure the rate of heat loss.

Have students measure the rate at which a frozen food thaws.

Have students interview restaurateurs about the amount of loss they experience each year due to foods being ruined by prolonged exposure to room temperature and write a report on their findings.

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TEACHER NOTES

"HEATING UP AND COOLING DOWN"

1. Perform experiment before presenting demonstration to class.

2. Link HEAT Program to each student's (group's) calculator. (It may be advisable to link the program the day before the experiment.

3. Link the temperature probe with the CBL through Channel 1.

4. When performing the hot water experiment, students should wear insulated gloves or use potholders. The data collected will be more authentic if the water temperature is kept constant on a hot plate.

5. If you do not have enough equipment for each group to do an individual experiment, set up a hot and cold station and have students rotate. Another alternative is to perform both parts of the experiment for the class, then link the data to each group.

6. Have students *gently* wipe off end of temperature probe using a facial tissue. Remind them to be careful not to touch the probe with their hands as this will contaminate the data collection.

7. Prepare **STUDENT INSTRUCTION SHEET** for each student and an **ACTIVITY SHEET** for each group.

STUDENT INSTRUCTIONS

"HEATING UP AND COOLING DOWN"

Overview: Perform investigations to determine the relationship between the heating or cooling time of an object and its recovery time to its original temperature.

Materials Required: TI-82/83 graphing calculator with cable link
CBL unit with temperature probe
Container of hot water (with hot plate, optional)
Container of ice water
Safety gloves or potholders
HEAT program for TI-82/83
STUDENT ACTIVITY SHEET

Procedure: Read all instructions before starting the experiment.

1. Assign tasks to each group member.
   Group leader - Keeps group on task; holds temperature probe in position
   CBL Monitor - Readies CBL for experiment and operates CBL
   Mathematician - Readies calculator for experiment and performs math operations
   Recorder - Record analysis of data; makes sure activity sheets are complete.

2. Verify that you have all necessary materials to complete the lab.

3. Link the CBL with the temperature probe in channel 1.

4. Link the CBL with the TI-82/83.

5. Activate the HEAT program. Collect a sample every 5 seconds. Pause when calculator displays "HIT ENTER TO START".

6. Turn CBL on. Make sure CBL is not in MODE status.

7. Place probe in HOT water (be careful!). Key "ENTER" on TI-82/83 calculator to start program. The insertion of the probe and starting of the calculator should be done simultaneously.

8. When CBL displays "DONE", this part of the experiment is complete. Keep probe in water during Step 9.

9. Copy the list in L3 to L1 and the list in L4 to L2 as quickly as possible.

   Press STAT
   Select EDIT
   Arrow cursor on top of L1.
   Press 2nd, L3, ENTER.
   Arrow over to list L2.
   Arrow cursor on top of L2.
   Press 2nd, L4, ENTER.

10. Activate HEAT program on TI-82/83. Use 5 seconds as sample collection time and pause when calculator displays 'HIT ENTER TO START".

11. Simultaneously remove probe from hot water and key **ENTER** to start program. Immediately after removal, gently wipe excess water off of probe with tissue.

12. When CBL displays "DONE", this part of the experiment is complete. Remove probe from water.

13. Complete ACTIVITY SHEET PART I up to 1a, then skip to 2 and complete up to 2a.

14. Using ICE WATER, complete Steps 7 - 12.

15. Complete ACTIVITY SHEET PART II up to 1a, then skip to 2 and complete up to 2a.

16. When finished, clean work area and return materials to appropriate place.

17. Complete ACTIVITY SHEETS PART I and PART II for homework.

18. Complete ACTIVITY SHEET PART III. Can be assigned for extra credit.

Conversion from Celsius to Fahrenheit in a LIST:

Place cursor *on top of* L5.
Type 1.8 * L2 + 32
Press ENTER
(Use L6 to convert L4)

REGRESSION and placing regression in "Y=" to GRAPH

TI-82
STAT
CALC
Select a regression (linear (ax + b), quadratic, exponential, power, etc.)
Type **L1, L2, ENTER**

"Y="
VARS
Select **STATISTICS**
Arrow over to **EQ**
Select **RegEQ**
ENTER

Key **GRAPH** to display scatter plot with regression curve.

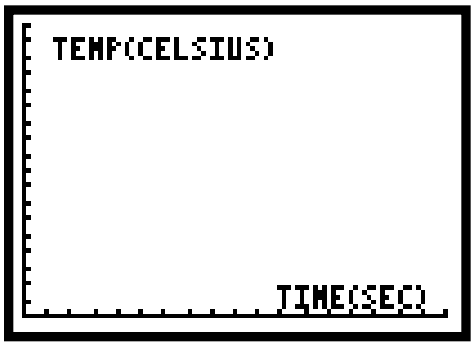
TI-83
STAT
CALC
Select a regression (linear(ax + b), quadratic, exponential, power, etc.)
Key **L1, L2, VARS**
Select **Y-VARS**
Select **Function**
ENTER
ENTER
Key **GRAPH** to display scatter plot with regression curve.

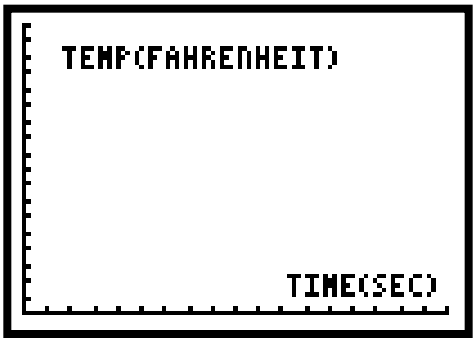
STUDENT ACTIVITY SHEET

PART I

1. Copy the data from lists L1 (TIME) and L2 (CELSIUS) into the chart below. In list L5, convert L2 to Fahrenheit. Copy the data from list L5 (Fahrenheit).

	A	B	C
1	Time (in sec)	Celsius	Fahrenheit
2	5		
3	10		
4	15		
5	20		
6	25		
7	30		
8	35		
9	40		
10	45		
11	50		
12	55		
13	60		
14	65		
15	70		
16	75		
17	80		
18	85		
19	90		
20	95		
21	100		
22	105		
23	110		
24	115		
25	120		
26	125		
27	130		
28	135		
29	140		
30	145		
31	150		
32	155		
33	160		
34	165		
35	170		
36	175		
37	180		





a. What is the relationship between temperature and time in each graph?

_____

_____

b. Explain why each graph has the shape it has.

_____

_____

c. Are the graphs for Celsius and Fahrenheit similar or different. Explain.

_____

_____

d. What type of function do you think you will get (linear, quadratic, exponential, some type of power function, etc.)? Explain why you chose this function.

_____

_____

e. Using the regression feature, write the function which you found to best fit your data.

__CELSIUS_____FAHRENHEIT_____

f. Did your group predict the correct function? _____

g. Write the correlation coefficient: r = _____
Given that 'r" will have a value of $-1 \leq r \leq 1$, with values of -1 and 1 representing perfect fits, did you get a good fit?

_____

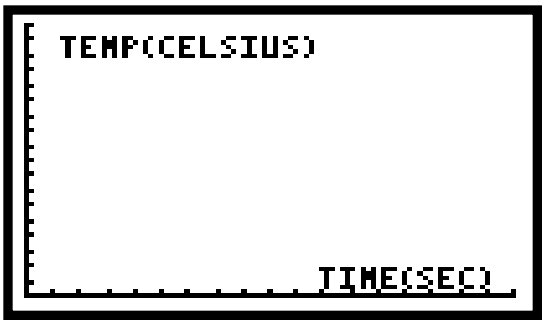
h. Is your function a representation of direct variation or inverse variation? Explain why.

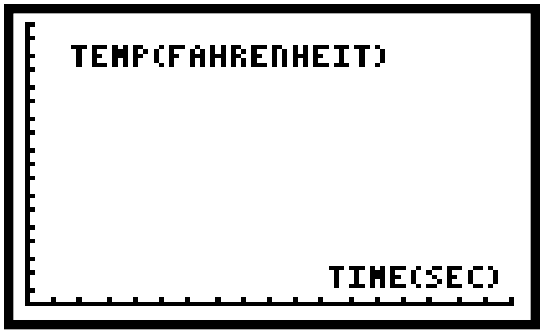
_____

_____

2. Copy the data from lists L3 (TIME) and L4 (CELSIUS) into the chart below. In list L6, convert L4 to Fahrenheit. Copy the data from list L6 (Fahrenheit).

	A	B	C
	Time (in sec)	Celsius	Fahrenheit
2	5		
3	10		
4	15		
8	35		
9	40		
10	45		
13	60		
14	65		
15	70		
16			
19	90		
20	95		
21	100		
22			
25	120		
26	125		
27	130		
28			
31	150		
32	155		
33	160		
34			
37	180		





a. What is the relationship between temperature and time?

_____

_____

b. Explain why your graph has the shape it has.

_____

_____

c. Are the graphs for Celsius and Fahrenheit similar or different. Explain.

_____

_____

d. What type of function do you think is graphed (linear, quadratic, exponential, some type of power function, etc.)? Explain why you chose this function.

_____

_____

e. Using the regression feature, write the function which you found to best fit your data.

CELSIUS_____ FAHRENHEIT_____

f. Did your group predict the correct function? _____

g. Write the correlation coefficient: r = _____
Given that 'r" will have a value of $-1 \leq r \leq 1$, with values of -1 and 1 representing perfect fits, did you get a good fit?

_____

h. Is your function a representation of direct variation or inverse variation? Explain why.

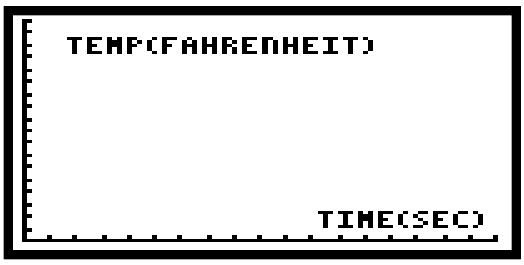
_____

_____

PART II

1. Copy the data from lists L1 (TIME) and L2 (CELSIUS) into the chart below. In list L5, convert L2 to Fahrenheit. Copy the data from list L5 (Fahrenheit).

	A	B	C
1	Time (in sec)	Celsius	Fahrenheit
2	5		
3	10		
4	15		
5	20		
6	25		
7	30		
8	35		
9	40		
10	45		
11	50		
12	55		
13	60		
14	65		
15	70		
16	75		
17	80		
18	85		
19	90		
20	95		
21	100		
22	105		
23	110		
24	115		
25	120		
26	125		
27	130		
28	135		
29	140		
30	145		
31	150		
32	155		
33	160		
34	165		
35	170		
36	175		
37	180		



a. What is the relationship between temperature and time?

_____

_____

b. Explain why your graph has the shape it has.

_____

_____

c. Are the graphs for Celsius and Fahrenheit similar or different. Explain.

_____

_____

d. What type of function do you think is graphed (linear, quadratic, exponential, some type of power function, etc.)? Explain why you chose this function.

_____

_____

e. Using the regression feature, write the function which you found to best fit your data.

CELSIUS _____ FAHRENHEIT _____

f. Did your group predict the correct function? _____

g. Write the correlation coefficient: r = _____
Given that 'r" will have a value of $-1 \leq r \leq 1$, with values of -1 and 1 representing perfect fits, did you get a good fit?

_____

_____

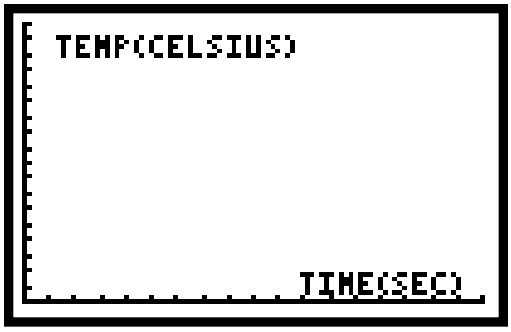
h. Is your function a representation of direct variation or inverse variation? Explain why.

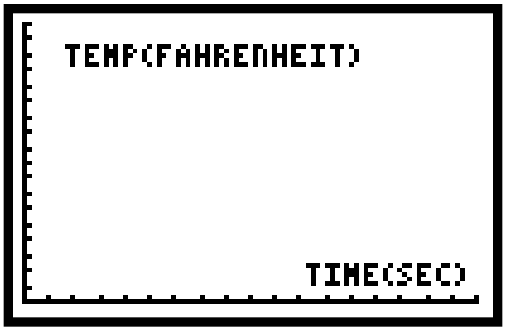
_____

_____

2. Copy the data from lists L3 (TIME) and L4 (CELSIUS) into the chart below. In list L6, convert L4 to Fahrenheit. Copy the data from list L6 (Fahrenheit).

	A	B	C
1	Time (in sec)	Celsius	Fahrenheit
2	5		
3	10		
4	15		
5	20		
6	25		
7	30		
8	35		
9	40		
10	45		
11	50		
12	55		
13	60		
14	65		
15	70		
16	75		
17	80		
18	85		
19	90		
20	95		
21	100		
22	105		
23	110		
24	115		
25	120		
26	125		
27	130		
28	135		
29	140		
30	145		
31	150		
32	155		
33	160		
34	165		
35	170		
36	175		
37	180		





a. What is the relationship between temperature and time?

_____

_____

b. Explain why your graph has the shape it has.

_____

_____

c. Are the graphs for Celsius and Fahrenheit similar or different. Explain.

_____

_____

d. What type of function do you think you will get (linear, quadratic, exponential, some type of power function, etc.)? Explain why you chose this function.

_____

_____

e. Using the regression feature, write the function which you found to best fit your data.

_____

f. Did your group predict the correct function? _____

g. Write the correlation coefficient: r = _____
Given that 'r" will have a value of $-1 \leq r \leq 1$, with values of -1 and 1 representing perfect fits, did you get a good fit?

_____

h. Is your function a representation of direct variation or inverse variation? Explain why.

_____

_____

GROUP NAME _____ DATE _____

Group leader _____

CBL Monitor _____

Mathematician _____

Recorder _____

STUDENT ACTIVITY SHEET
PART III

1. How would the graph of the data change or not change if the time between sample selections was changed to 2 seconds? 10 seconds?

_____

_____

_____

_____

2. You are making a cake that calls for one cup of boiling (212 degrees Fahrenheit) water. When the water reaches the boiling point, your friend phones. If you talk to your friend for five minutes, what will be the temperature of the cup of water? Support your answer.

_____

_____

_____

_____

3. Approximately how long will it take a dish of ice cream (frozen at 32 degrees Fahrenheit) to melt completely to room temperature? Are their any factors that might affect the melting rate of the ice cream that should be considered?

_____

_____

_____

_____

4. Your mother has prepared a turkey for Thanksgiving dinner. The directions say to cook the turkey until it has an internal temperature of 185 degrees Fahrenheit. Do you think the turkey will cool at the same rate as the temperature probe inserted in HOT water? Explain how you determined your prediction. What factors did you need to consider in arriving at your conclusion that did not need to be considered when you cooled the temperature probe?

_____

_____

_____

_____

5. Give examples where knowing the cooling rate or heating rate of an object could be useful in real-life applications.

_____

_____

_____

_____

SAMPLE ANSWERS

PART I

1. Data will vary. Sample graph.

a. As time increases, temperature increases.

b. same as #1a.

c. The basic shape is the same; the scale is different.

d. Power

e. Answers will vary.

f. Answers will vary.

g. Answers will vary.

h. Direct variation. "x" increases as "y" increases.

2. Data will vary.

a. As time increases, temperature decreases.

b. Answers will vary. (It gradually decreases and then levels off.)

c. Similar. Explanations will vary.

d. Power.

e. Answers will vary.

f. Answer will vary.

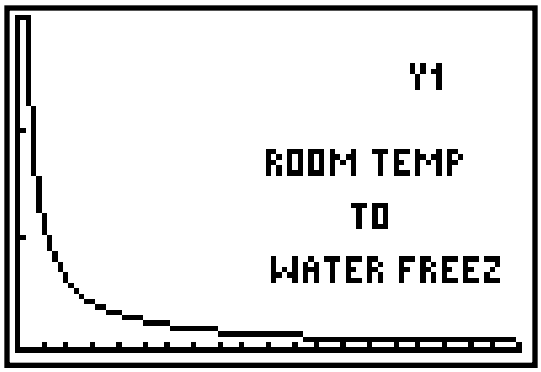
g. Answers will vary.

h. Inverse variation.

SAMPLE ANSWERS

PART II

1. **Data and graphs will vary.**



   a. **As time increases, temperature increases.**

   b. **same as #1a.**

   c. **The basic shape is the same; the scale is different.**

   d. **Power**

   e. **Answers will vary.**

   f. **Answers will vary.**

   g. **Answers will vary.**

   h. **Inverse variation. "x" increases as "y" decreases.**

2. **Data will vary.**

   a. **As time increases, temperature increases.**

   b. **Answers will vary. (It gradually increases and then levels off.)**

   c. **Similar. Explanations will vary.**

   d. **Power.**

   e. **Answers will vary.**

   f. **Answer will vary.**

   g. **Answers will vary.**

   h. **Direct variation.**

SAMPLE ANSWERS

PART III

1. **The basic shape would be the same for each graph, but the first graph would be smaller and more closely spaced and the second graph would be larger and more widely spaced.**

2. **Answers will vary, but using the power regression for Fahrenheit cool down, the students will get a good approximation.**

3. **Use the regression for returning ice water to room temperature. This will give a good approximation. answers will vary - samples, consider the container the ice cream is served in; the type of ice cream; etc.**

4. **No, the mass of the turkey will cause it to cool down at a slower rate.**
   Various answers - examples, need to consider size of turkey; need to consider what the turkey is placed on to be served; etc.

5. **Answers will vary. Examples - Salmonella, food preservation, etc.**

HEATING UP AND COOLING DOWN

STUDENT ACTIVITY PACKET

DATE _____

GROUP NAME _____

Group leader _____

CBL Monitor _____

Mathematician _____

Recorder _____